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EFFECT OF DIETARY INCLUSION OF POMERGRANATE PEEL POWDER (*Punica grantum*) ON GROWTH PERFORMANCE AND SOME PHYSIOLOGICAL PARAMETERS OF BROILER CHICKS

Azza Elsebai, , El-Tahawy W. S.[2], Fatma M. El-Attar [2] and Asmaa Sh. ELnaggar[2]

[1]Poult.Pro.Dep.,Fac.of Agric. (El-Shatby), Alexandria Uni., Alexandria, Egypt, [2]Dept. of Anim. and Poult. Prod., Fac. of Agric., Damanhour Uni., Egypt

Corresponding author: Asmaa Sh. Elnaggar; Email: asmaa.elnaggar@agr.dmu.edu.eg

ABSTRACT

This study aimed to evaluate the impact of different levels of pomegranate peel powder *(Punica grantum*) supplemented diet on productive performance, protein profile, and carcass characters of broiler chicks. A total of 180 unsexed broiler chicks (*Arbor Acres*) at the age of seven-day-old chicks were randomly divided into five treatments (36 chicks each) divided into six replicates (each replicate of six chicks). The first group was fed the basal diet (control); while the 2nd, 3rd, 4th, and 5th groups were fed the basal diet supplemented with 0.25, 0.50, 1.00, and 1.50 % pomegranate peel powder, respectively. Data revealed that treatment groups with supplemented different levels of pomegranate peel powder had greater productive performance, compared to the control group. All treatments with different levels of pomegranate peel powder increased total protein, globulin, RBCs, Hb, PCV, and WBCs ,while decreasing abdominal fat, AST, and ALT compared to the control group (within normal range). In conclusion, it can be considered that pomegranate peel powder supplementation in the diet improved the growth performance and physiological status of the broilers without any adverse effects on the blood parameters of broiler chicks.

Keywords: Pomegranate peel powder, Broilers, Performance, Carcass characteristics, Blood parameters.

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INTRODUCTION

Diet plays a pivotal role in maintaining animal health, productive and reproductive performance of farm animals and poultry. The importance of the consumption of foods with a high content of antioxidants like fruits and vegetables is obvious **(Zafra et al., 2007).** It is well known that including antibiotics in poultry diets results in health problems leading to bacteria resistance against medications administered by humans **(Arif *et al.*, 2016)**. In poultry new supplements such as probiotics, prebiotics, enzymes, and herbs have been suggested in order to increase the efficiency of feed utilization and maintain the general health status of birds (**Ghazalah, *et al.*, 2022)**. Pomegranate (*Punica granatum L.*) is an important fruit crop in Egypt. Increasing agro-industrial units for producing pomegranate juice has led to increased processing of by-products including peels and seeds. These processes have led to production of high quantities of pomegranate byproduct biomass. Fresh pomegranate biomass contains high levels of moisture and soluble sugars **(Shabtay *et al*., 2008)**. If it cannot use by farmers and industries as well as medical activities cause serious environmental problems. Pomegranate is one of the oldest known drugs. It is mentioned in the herbs papyrus of Egypt written in about 1550 BC **(Ross 1999).** Moreover, it has been reported to have antimicrobial activity against a range of Gram positive and negative bacteria **(McCarrell *et al.*, 2008)**. Pomegranate (*Punica granatum*) by-products are such types of that show exciting nutritional and health-promoting features due to the presence of bioactive compounds (**Kishawy *et al*., 2019; Viuda-Martos *et al*., 2010)**. Pomegranate is a native mediterranean plant that has been widely used by ancient Egyptians in folk medicine (**Gil *et al.*, 2000)**. Edible parts of fruit comprise 78% juice and 22% by-products, while *by*-products contain approximately 52% of the total weight of fruit; the inedible parts like a seed, husk, peel, etc., have a lot of bioactive compounds like polyphenols, ellagitannins, vitamins, metals, and polyunsaturated greasy acids. In particular, by-products of pomegranate have antioxidant, anti-carcinogenic, and antimicrobic effects **(Seeram *et al.*, 2005; Reddy *et al.*, 2007; Bostami *et al.*, 2015)**.

Pomegranate peel also contains substantial amounts of flavonoids, catechins, ellagic acid, flavones, and anthocyanidins, in addition to other polyphenolic constituents **(Naveena *et al*. 2008).** There are a number of

inconsistencies in the literature on whether the powder, extract, and pomace of pomegranate peel powder (PPP) influence the growth performance of broiler birds and other livestock species. Scientific reports have shown that PP (extract and powder) improved body weight, feed intake, feed efficiency, carcass and organ parameters in broilers (**AlShammari *et al*., 2019; Kishawy *et al.*, 2019; Sharifian *et al.* 2019; Abdel-Baset *et al*., 2022)**, and in quails (**Abbas *et al.,* 2017**). Supplementation of pomegranate peel powder meal (PPPM) had a significant influence on the growth traits of the broiler birds **(Akurua *et al.*, 2020; Abdel Baset *et al.,* 2020)**. The aim of this study aimed to evaluate the impact of different levels of pomegranate peel powder supplemented diet on productive performance, carcass traits, protein profile, liver, and kidney functions of broiler chicks.

MATERIAL AND METHODS

The current study was performed at the Animal and Poultry Research Centre of the Animal and Poultry Production Department, Faculty of Agriculture (El-Bostan Farm), Damanhour University.

Chemical properties of pomegranate peel powder

The pomegranate peel powder material used in the experiment was obtained in powder form from a commercial source in Damanhour City, Beheira Governorate. The major chemical analysis of pomegranate peel powder (*Punica grantum*) contains crude protein, carbohydrate, ash, crude fiber, and moisture was 3.00, 94.00, 4.00, 8.20, 6.10 % respectively.

Ethical approval:

All treatments and birds care procedures were approved by the Institutional Animal Care and Use Committee at Damanhour University, Egypt. The authors declare that the procedures imposed on the birds were carried out to meet the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Birds and experimental design

A total of 180 unsexed broiler chicks (*Arbor Acres*) at the age of seven-day-old chicks were randomly divided into five treatments (36 chicks each)

divided into six replicates (each replicate of six chicks). Chicks were similar in live body weight which ranged from (180 to 184 g).

All treatments and birds care procedures were approved by the Institutional Animal Care and Use Committee in Damanhour University, Egypt. Authors declare that the procedures imposed on the birds were carried out to meet the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Chicks were fed the experimental diets *ad libtium* and clean fresh water was available for chicks at all times. The feeding trial was extended to 42 days of age. Two basal diets were formulated in **Table (1)** to meet the nutrient requirements of chicks during the starter period (1-21 days) and grower period (22-42 days), (**NRC, 1994**). Experimental groups were as follows: The first group was fed a basal diet without supplementation and saved as the control group, while the 2nd, 3rd, 4th , and 5thgroups were fed a basal diet supplemented with different levels of pomegranate peel powder 0.25,0.50, 1.00, and 1.50 % / kg of diet respectively.

Table (1): Composition and calculated analysis of basal and experimental diets of broiler's ingredients (%)

Diets	**Starter period (1-21 days)**	**Grower period (22-42 days)**
Ingredients, %		
Yellow Corn	54.00	59.00
Soybean Meal (46%)	27.00	21.20
Full fat soya,	5.00	7.00
Glutein, 60%	8.00	7.00
Soya oil	1.50	1.30
Mono calcium Phosphate	1.65	1.65
Lime stone	1.75	1.75
L-lysine	0.25	0.25
DL –methionine	0.20	0.20
Salt (Na Cl)	0.35	0.35
Premix *	0.30	0.30
Total	**100**	**100**
Calculated analysis		

Crude Protein %	23	21
ME (kcal/kg)	3050	3100
Crude Fiber, %	2.70	2.70
Ether extract, %	4.10	4.45
Calcium, %	1.01	1.01
Phosphorus available%	0.50	0.51
Methionine %	0.66	0.61
Lysine %	1.33	1.25
Methionine+Cystine %	1.05	0.98

*: Each kg of vitamin and mineral mixture contains: 12 M IU vitamin A; 5 M IU D3; 80000 mg E; 4000 K mg; 4000 mg B1; 9000 mg B2; 4000 mg B6; 20 mg B12; 15000 mg pantothenic acid; 60000 mg Nicotinic acid; 2000 mg Folic acid; 150 mg Biotin; 400000 mg Choline Chloride; 15000 mg Copper sulphate; 1000 mg calcium Iodide; 40000 mg ferrous sulphate ; 100000 mg Manganese oxide ; 100000 mg Zinc oxide and 300 mg Selenium selenite.

Housing and management

The chicks were kept in breeding enclosures in an open-sided house. During the first week, they received 23 hours of light, and from the second week until the end of the fattening period, they received 20 hours of light. This standard light schedule was recommended for commercial broiler chick raising. All chicks were initially incubated at 33°C, which was subsequently lowered to 30-27 °C during the second week, and with the aid of fans, an average temperature of 24 to 26 °C was maintained from 3 to 6 weeks of age.

Data collection

Performance parameters including individual live body weight (LBW, g), body weight gain (BWG, g), and feed consumption (FC, g) were recorded throughout the trial period (1-6 wk. of age). For each replicate within treatment groups, the feed conversion ratio (feed/gain ratio, FCR) was calculated.

Blood sampling and haemato-biochemical parameters

At 42 days of age, 6 chicks from each treatment were randomly taken at 08:00 – 09:00 am and about 3 ml of blood were collected from the brachial vein into vacationer tubes with or without containing K3-EDTA (1 mg/mL), coagulated blood samples were centrifuged at 2000g for 20 min and the clear

serum was separated and stored in a deep freezer at -20°C until biochemical analysis. Non-coagulated blood was divided into two parts. The first part was used to test shortly after collection for estimating the blood picture, whereas the second part was centrifuged at 2000g for 20 min and the clear plasma was separated and stored in a deep freezer at -20°C until biochemical analysis. All blood biochemical variables were determined calorimetrically using commercial kits.

Red blood cells count (RBCs $10^6/mm^3$) and white blood cell count (WBCs $10^3/mm^3$) were calculated according to (**Feldman *et al.*, 2000**). Hemoglobin (Hb) concentration (g/dl) and the percentage of packed cell volume (PCV %) were measured according to (**Drew *et al.*, 2004**). A thin blood film was prepared by using a small drop of blood. The blood film was completely dried before staining using Giemsa stain. The film was washed in distilled water and dried. Differential leucocyte counts were examined in each blood film by using a light microscope with 1000* Blood WBC differential count was recorded by determining the percentage of lymphocytes and heterophils according to (**Feldman *et al.*, 2000**). Heterophils to lymphocytes ratio (H/L) was calculated by dividing the number of heterophils (H) by the number of lymphocytes (L).

Serum total proteins, albumin, were measured according to guidelines and recommendations of Armstrong and Carr (1965); Doumas et al. (1971). Serum globulin was calculated by subtraction of albumin from total proteins since the fibrinogen usually comprises a negligible fraction (Sturkie, 1986). The albumin to globulin ratio was also calculatedThe transaminase enzymes activities of serum aspartate aminotransferase (AST) and serum alanine aminotransferase (ALT), as U/dl, were determined by the calorimetric method of **Reitman and Frankel (1957)**. Alkaline phosphatase (ALP) concentration was determined according to the colorimetric method of **Bauer (1982)**. The creatinine level was estimated according to **Husdan and Rapoport (1968)**, while, serum uric acid was determined colorimetrically according to **Majkic-Singh *et al.* (1981)**.

Slaughter traits

Six chicks from each treatment were taken randomly at the end of the experiment and slaughtered after a 12-hour fastening period to determine carcass characteristics. Abdominal fat was removed from the gizzard and abdominal region, and each carcass was individually weighed and estimated

relatively to the pre-slaughtered weight and was removed, weighed, and the weight of each organ was estimated relative to the pre-slaughtered weight

Statistical analysis

Data obtained were analyzed using the GLM procedure (Statistical Analysis System (**SAS, 2006**) by one-way ANOVA using the following model:

$$Yij= \mu+ Ti + eij$$

Where Y is the dependent variable; μ is the general mean; T is the effect of experimental treatments and e is the experimental random error. Before analysis, all percentages were subjected to logarithmic transformation (log10x+1) to normalize data distribution. The differences among means were determined using Duncan's new multiple range test (**Duncan, 1955**).

RESULTS AND DISCUSSIONS

Productive performance traits

The effect of live body weight (LBW) of broiler chicks fed on diets supplemented with different levels of pomegranate peel powder (*Punica grantum*) (PPP) is present in **Table (2)**. Obviously, the results showed that the different treatments have has significant differences at 3 weeks (P=0.001) and 6 weeks (P=0.001) of age. The percentage of that increase in four treatment groups compared to control one was 119.14, 121.79, 117.05, and 116.98 % for different levels of pomegranate peel powder at 42 days of age, respectively.

These results in **Table (3)** indicated that the studied levels of pomegranate peel powder enhanced the BWG of broiler chicks. That the different treatments have significant differences in BWG at 1-3, 3-6, and 1-6 weeks of age. Thus, the percentages of the differences compared with the control group mean were 121.04, 123.93, 118.85 and 118.52 % for different levels of pomegranate peel powder, at 42 days of age, respectively.

The effect of feed consumption (FC) of broiler chicks fed diets supplemented with different levels of pomegranate peel powder is shown in **Table (4)**. The differences in levels studied treatments were insignificant in feed consumption during 1-3, 3-6, and 1-6 weeks of age.

Table (2): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on live body weight of broiler chicks.

Dietary supplementations	Live body weight (g) (LBW)		
	1 wk	**3 wk**	**6 Wk**
Control	180.00	950.78[b]	1880.22[b]
PPP 0.25 %	182.00	1080.11[a]	2240.12[a]
PPP 0.50 %	183.00	1090.00[a]	2290.00[a]
PPP 1.00 %	180.00	1060.06[a]	2200.80[a]
PPP 1.50 %	184.00	1100.11[a]	2199.55[a]
SEM	3.90	9.88	11.88
P value	0.987	0.001	0.001

[a,b]Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

Table (3): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on body weight gain of broiler chicks.

Dietary supplementations	Body weight gain (g) (BWG)		
	1-3 wk	**3-6 wk**	**1-6 wk**
Control	770.78[b]	929.44[b]	1700.22[b]
PPP 0.25 %	898.11[a]	1160.01[a]	2058.12[a]
PPP 0.50 %	907.02[a]	1200.00[a]	2107.00[a]
PPP 1.00 %	880.06[a]	1140.74[a]	2020.8[a]
PPP 1.50 %	916.11[a]	1099.55[a]	2015.55[a]
SEM	11.90	17.90	19.98
P value	0.0001	0.001	0.001

[a, b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

Table (4): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on feed consumption of broiler chicks.

Dietary supplementations	Feed consumption (g feed / bird/ period)		
	1-3 wk	3-6 wk	1-6 wk
Control	1400.78	1800.56	3201.34
PPP 0.25 %	1350.33	1928.56	3278.89
PPP 0.50 %	1360.22	1993.44	3353.66
PPP 1.00 %	1310.17	1973.72	3283.89
PPP 1.50 %	1376.22	1990.06	3366.28
SEM	22.98	18.89	23.90
P value	0.068	0.061	0.071

SEM, Standard error of mean; PPP, pomegranate peel powder.

Table (5): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on feed conversion of broiler chicks.

Dietary supplementations	Feed conversion (g feed/ g body weight gain) (FCR)		
	1-3 wk	3-6 wk	1-6 wk
Control	1.816^{a}	1.937^{a}	1.882^{a}
PPP 0.25 %	1.504^{b}	1.663^{b}	1.593^{b}
PPP 0.50 %	1.500^{b}	1.661^{b}	1.592^{b}
PPP 1.00 %	1.489^{b}	1.730^{b}	1.625^{b}
PPP 1.50 %	1.502^{b}	1.810^{ab}	1.670^{b}
SEM	0.071	0.087	0.099
P value	0.001	0.001	0.0001

^{a,b,} Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

From **Table (5)** shows treated broiler chicks fed pomegranate peel powder with different levels had significantly better FCR than the control group. The percentages of improvement in supplemented groups compared with the control group were 84.64, 84.59, 86.34, and 88.74 % for different levels of pomegranate peel powder at 42 days of age, respectively. This

improvement in feed conversion ratio can be attributed to the increase in body weight gain observed in this study (**Table 3**).

Improvements in performance traits

The present results showed significant improvements in LBW, BWG, and FCR for all treatments compared with the control group. Among different treatments, the highest improvement in LBW, BWG, and FCR was 12.17 %, 12.39 %, and -17.26 %, respectively with pomegranate peel powder at 0.50 %. While the lowest improvement was 11.69 %, 11.85 %, and -13.21%, respectively with pomegranate peel powder at 1.50 %.

The improvement may be due to essential oil compounds in the pomegranate peel powder having significant activity in inhibiting the growth of bacteria (anti-microbial activity) that promotes the performance of the intestinal flora thereby improving digestion and enhancing the utilization of energy, leading to improved growth. These results are coincident with the results of **Hamid (2019)** found that improvement of BW and BWG in birds feed pomegranate peel powder due to the fact that the pomegranate peel powder contains important chemicals, which include various types of alkaloids such as flavonoids, glycosides and tannins. Contains useful vehicle saturated fats such as sterols and plant steroids

The improvement in the birds feed pomegranate peel powder may perhaps be due to the growth-promoting benefits of pomegranate peel which has been linked to its antioxidant and antimicrobial properties **(Middha *et al.*, 2013; Thema *et al.* 2019)**. The presence of proanthocyanidin in pomegranate peel enables it to improve pancreatic and small intestinal digestive enzyme functions, and prevent the deleterious influence of free radicals on intestinal enterocytes; thus, leading to enhanced nutrient absorption **(Tavarez *et al.*, 2011; Middha *et al.*, 2013; Reddy *et al.*, 2014).** The antibacterial and antimicrobial potential of pomegranate peel is associated with its tannin content. The tannins enable pomegranate peel to decrease the population of harmful gut microbes, inhibit pathogenic microbial metabolism and the activities of harmful microbial enzymes by preventing oxidative phosphorylation **(Viuda-Martos *et al.*, 2010).** These effects lead to an overall improvement in the availability and absorption of nutrients in the intestinal lumen, with a resultant improvement in bird performance (**Abdollazadeh *et al.*, 2011; Hamady *et al.*, 2015, Saleh *et al.*, 2018)**. Our result on FCR agrees with the findings of **Ahmadipour *et al.*, (2018), El-Ghousein and Al-**

Beitwawi (2009). **Saeed *et al*. (2018)** informed that supplementing a pomegranate-derived additive to feed has demonstrated their potential for enhancing the growth performance and health status of birds without using growth-promoting antibiotics. Pomegranate by-products have good nutritional and health-raising faces (**Viuda-Martos *et al*., 2010; Goñi *et al*., 2007; Brisibe *et al*., 2009; Hu *et al*., 2015**). Therefore, the dietary supplementation of PPP, which contained natural antioxidants, may improve feed efficiency by reducing oxidative damage in broilers fed diet and the positive effect that plant feed additives exert on gastro-intestinal enzymatic activity and thus enhancing nutrients absorption and digestibility **(Banerjee *et al*., 2013; Gamal *et al*., 2015; Rajaian *et al*., 2013; Bozkurt *et al*., 2008; Hamady *et al*., 2015; Rezvani and Rahimi, 2017)**.

Blood constituents

Hematological parameters

The results of **Table (6)** show data of RBC's count (10^6/mm3) was significantly increased (P=0.001) with different levels of pomegranate peel powder. Thus, the percentage of the differences compared with the control mean was 168.83, 177.06, 168.39and 163.63% for treated groups, respectively.

Table (6): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on hematological parameters of broiler chicks.

Dietary Supplementations	Hematological parameters			CBC indices		
	RBC's (10^6/mm^3)	Hb (g/dl)	PCV (%)	MCV (fl)	MCH (pg)	MCHC (g/dl)
Control	2.31^b	9.27^b	35.98^b	122.86^a	30.80	25.76^b
PPP 0.25 %	3.90^a	12.90^a	42.99^a	110.23^b	33.08	30.01^a
PPP 0.50 %	4.09^a	11.99^a	41.87^a	102.37^b	29.32	28.64^a
PPP 1.00 %	3.89^a	12.87^a	40.98^a	105.35^b	33.08	31.41^a
PPP 1.50 %	3.78^a	11.88^a	41.90^a	110.85^b	31.43	28.35^a
SEM	0.178	2.90	3.99	12.90	2.90	1.87
P value	0.001	0.002	0.001	0.003	0.087	0.003

^{a,b} Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder. RBCs, = red

blood cell; PCV, packed cell volume; MCHC=Mean cell hemoglobin concentration; MCH = Mean cell hemoglobin; MCV= Mean cell volume

The results showed that treating the broilers by diets supplemented with different levels of pomegranate peel powder resulted in a significant increase (P=0.002) in blood hemoglobin concentration (Hb) when compared with the control group. Thus, the percentage of differences compared with the control mean was 139.16, 129.34, 138.83, and 128.16% for treated groups, respectively. At the end of the treatment period, the results in **Table (6)** showed that broiler's PCV values were significantly affected (P=0.001) by different levels of pomegranate peel powder when compared with the control group. Thus, the percentage of differences compare to the control mean were 119.48, 116.37, 113.89 and 116.45 % for different levels of treated groups, respectively.

The mean corpuscle (cell) volume (MCV) is a measurement of the average size of the RBCs. The results showed that treating the broilers with diets supplemented with different levels of pomegranate peel powder resulted in differences observed between treatments in MCV. The value of MCV the percentage of differences compare to the control mean were 89.72, 83.32, 85.74 and 90.22 %for different levels of treated groups, respectively, which indicates an increase in the size of red blood cells with this treatment compared to other treatments.

The results showed that treating the broilers with diets supplemented with different levels of pomegranate peel powder resulted in differences observed between treatments in MCHC. The value of MCHC the percentage of differences compared to the control mean were 116.49,111.18, 121.93, and 110.05% for different levels of treated groups, respectively.

Also, the results of **Table (7)** show the different treated groups had improved the WBC's, lymphocytes (%), and H/L ratio. On the other hand, no differences were observed between treatments in heterophile and monocytes. Broiler WBCs count was increased with the increase of the pomegranate peel powder levels. The percentages of improvement in supplemented groups compared with the control group were 140.81, 126.17, 124.66, and 120.68 % for different levels of pomegranate peel powder at 42 days of age, respectively. Also, data presented in **Table (7)** that pomegranate peel powder had a significant decreasing effect on heterophils (H) during the treatment

period. The percentages of decrease in supplemented groups compared with the control group were 75.55, 76.93, 81.25, and 79.50 % for different levels of pomegranate peel powder at 42 days of age, respectively.

Table (7): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on leukocytic components of broiler chicks.

Dietary Supplements	White blood cells and differential leukocytes counts				
	WBC's (10^3/mm^3)	**Heterophils (%)**	**Lymphocyte (%)**	**H/L**	**Monocyte (%)**
Control	19.87^b	32.64^a	40.87^b	0.871^a	14.99
PPP 0.25 %	27.98^a	24.66^b	46.99^a	0.524^b	15.01
PPP 0.50 %	25.17^a	25.11^b	45.99^a	0.546^b	13.99
PPP 1.00 %	24.77^a	26.52^b	44.17^a	0.591^b	14.98
PPP 1.50 %	23.98^a	25.95^b	46.09^a	0.562^b	12.99
SEM	3.98	2.98	2.00	0.098	2.09
P value	0.0001	0.002	0.001	0.002	0.087

^{a,b} Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder. WBCs, White blood cell

Data indicated that pomegranate peel powder had a significantly increasing effect on lymphocytes (L) during the treatment period. The percentages of improvement in supplemented groups compared with the control group were 114.97, 112.52, 108.07, and 112.77 % for different levels of pomegranate peel powder at 42 days of age, respectively. The data at the end of the treatment period indicated that pomegranate peel powder levels caused a significant decreasing effect (P=0.002) in the H/L ratio when compared with the control. The percentages of improvement in supplemented groups compared with the control group were 60.16, 62.68 , 67.85 and 64.52 % for different levels of pomegranate peel powder at 42 days of age, respectively.

Hematological parameters are good indicators of the physiological status of animals (**Khan and Zafar, 2005**), and are related to the blood and blood-forming organs (**Waugh *et al.*, 2002**). **Wu *et al.*, (2017)** showed that supplementation with pomegranate peel increased RBC counts in broiler.

Hemoglobin is the main protein that carries oxygen in RBCs, and some studies have shown that it plays an important role in innate immune responses

Blood biochemical parameters

At the end of the treatment period, the results of the means in **Table (8)** showed that the broiler's serum total protein was significantly affected (P=0.001) by pomegranate peel powder treatments when compared with the control group. There are no significant differences between levels of pomegranate peel powder on broilers, according to Duncan's letters. Thus, the percentage of differences compare to the control mean were 114.65, 115.84, 117.04, and 117.54% for different treated groups, respectively. From **Table (8)** the results indicated a non-significant effect of pomegranate peel powder treatments on albumin concentration at the end of the treatment period. Serum globulin concentration was significantly affected by pomegranate peel powder treatments when compared with the control group at the end of the experimental period as presented in **Table (8)**.

Table (8): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on protein profile of broiler chicks.

	Protein profile (g/dl)			
Dietary supplementations	**Total protein**	**Albumin**	**Globulin**	**A/G ratio**
Control	5.87[b]	3.20	2.67[b]	1.199
PPP 0.25 %	6.73[a]	3.30	3.43[a]	0.962
PPP 0.50 %	6.80[a]	2.87	3.93[a]	0.730
PPP 1.00 %	6.87[a]	3.13	3.74[a]	0.837
PPP 1.50 %	6.90[a]	3.10	3.82[a]	0.816
SEM	0.987	0.187	0.110	0.009
P value	0.001	0.065	0.002	0.087

a,b,c Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

The percentage of increase in treatment groups compared to the control group was 128.46, 147.19, 140.07, and 143.0 % at 42 days of age, respectively. While the results indicated a non-significant effect of pomegranate peel powder treatments on the A/G ratio at the end of the treatment period. These results are coincident with the results of **Eunice *et al.***

(2020) found that the improvement seen in the serum total protein and albumin had been linked to enhanced protein digestibility **(Oliveira *et al.*, 2020). Krames (2010)** reported that associated elevated total protein levels to increased serum protein synthesis, which suggests normal liver function and enhanced growth performance.

Liver function indicators

Table (9) shows at the end of the treatment period, the results of means revealed that the broiler chicks treated with the pomegranate peel powder levels had significantly lower (P=0.001) serum AST means when compared with the control. Thus, the percentage of the differences compared with the control mean was 91.46, 92.61, 94.03, and 91.37% for pomegranate peel powder groups, respectively. Also, the results showed that the means of serum ALT was significantly lower (P=0.0001) in the pomegranate peel powder - treated groups when compared with the control group. Thus, the percentage of the differences compared with the control mean was 83.34, 85.46, 85.46, and 90.89 % for pomegranate peel powder groups, respectively. While the results showed that the means of serum alkaline phosphatase (ALP) was non-significantly increased compared to the control group.

Table (9): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on liver and kidney functions of broiler chicks.

Dietary supplementations	Liver and kidney functions				
	AST (U/L)	**ALT (U/L)**	**ALP (IU/L)**	**Creatinine (mg/dl)**	**Uric acid (mg/dl)**
Control	71.39[a]	61.29[a]	212.1	1.03	2.23
PPP 0.25 %	65.30[b]	51.08[b]	206.9	0.833	2.16
PPP 0.50 %	66.11[b]	52.38[b]	200.5	0.847	2.26
PPP 1.00 %	67.13[b]	53.38[b]	204.3	0.689	2.31
PPP 1.50 %	65.23[b]	55.71[b]	207.9	0.857	2.25
SEM	4.90	3.90	11.90	0.087	0.009
P value	0.001	0.001	0.0701	0.002	0.0765

a,b Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

Results presented in **Table (9)** showed the changes in serum creatinine and uric acid concentrations of broilers treated pomegranate peel powder levels at the treatment period the results of the present study showed no significant in serum uric acid and creatinine of broiler chickens with pomegranate peel powder treatments at the end of the treatment period.

Serum AST which is an important intracellular enzyme is often used to assess hepatocellular injury. These results are coincident with the results of **(Hosseini-Vashan *et al.*, 2016; Attia *et al.*, 2015)**. The significant reduction in AST levels by pomergranate peel powder indicates that PPP had no harmful effect on liver function. **Zuonongo, (2013)**, **Sharifian *et al.*, (2019)** who reported that the dietary pomegranate peel extract increased the levels of these metabolites in broiler birds. However, these authors reported that dietary inclusion of pomegranate peel extract had no effect on AST levels in the birds. Serum AST enzyme concentrations were reduced by pomegranate peel powder. A reduction in AST concentration was also reported by **Abdel Baset *et al.* (2020)**, where liver enzymes declined in pomegranate peel treatment. Therefore, **Abbas *et al.* (2017)** reported that the addition of pomegranate peel powder to diets reduced liver enzymes in Japanese quails. A previous study confirmed that phenolic compounds result in a decrease in AST concentrations in birds **(Ghasemi-Sadabadi *et al.*, 2020).** Hence, it seems that the antioxidant activity of pomegranate peel powder may protect the liver against oxidative stress, which inhibits liver tissue damage **(Saleh *et al.*, 2018).**

Slaughter traits

Table (10) summarizes the effects of pomegranate peel powder treatment on carcass characteristics in broiler chicks at the end of the study period. Overall, pomegranate peel powder treatments enhanced the percentage of the carcass by 104.86, 106.48, 103.69 and 102.96 in the control group, respectively. But, weight percentages of liver, gizzard, and pancreas were not significantly different among experimental groups overall chick abdominal fat (%) was considerably reduced (P=0.0001), reaching 71.25, 76.34, 77.85 and 86.65% of the control group chicks, respectively.

Table (11) summarizes the effects of pomegranate peel powder treatment on the percentage of lymphoid organs spleen, thymus, and bursa increased non-significantly.

These findings are consistent with those of **Le Bihan-Duval *et al.* (1999); Jamroz *et al.* (2005); Murugesan *et al.* (2015)** had shown that an

increase in the proportion of eviscerated muscles (particularly the breast) is needed for increased profitability in the broiler industry. Our results agree with previous reports **(Sarica and Urkmez 2016; Al-Shammari *et al.*, 2019; Gamal *et al*., 2015).**

Table (10): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on carcass traits of broiler chicks.

Dietary Supplements	**Carcass traits (%)**				
	Carcass	**Liver**	**Gizzard**	**Pancreas**	**Abdominal fat**
Control	69.74[b]	1.64	1.09	0.560	0.727[a]
PPP 0.25 %	73.13[a]	1.60	1.99	0.555	0.518[b]
PPP 0.50 %	74.26[a]	1.87	1.11	0.577	0.555[b]
PPP 1.00 %	72.32[a]	1.93	1.14	0.544	0.566[b]
PPP 1.50 %	71.81[a]	1.86	1.23	0.567	0.630[b]
SEM	4.90	0.098	0.011	0.087	0.098
P value	0.001	0.067	0.087	0.089	0.0002

a,b Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

Table (11): Effect of dietary inclusion with different levels of pomegranate peel powder (*Punica grantum*) on lymphoid organs (%) of broiler chicks.

Dietary Supplementations	**Lymphoid organs** (%)		
	Spleen	**Thymus**	**Bursa**
Control	0.363	0.417	0.357
PPP 0.25 %	0.390	0.580	0.313
PPP 0.50 %	0.332	0.600	0.253
PPP 1.00 %	0.410	0.598	0.230
PPP 1.50 %	0.380	0.531	0.254
SEM	0.087	0.008	0.087
P value	0.065	0.087	0.012

a,b Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; PPP, pomegranate peel powder.

CONCLUSION

It can be considered that dietary supplementation of Pomegranate Peel Powder (PPP) at 0.25, 0.5 and 1.00 % to the diet improved productive performance, some blood parameters, and carcass characteristics of broiler chicks.

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الملخص العربي

تأثير الاضافة العلفية للمستويات المختلفه من قشر الرمان على أداء النمو وبعض الصفات الفسيولوجية لكتاكيت التسمين

عزة عبد الله السباعي[1]؛ وليد صلاح الطحاوي[2] ؛ فاطمه العطار [2] ؛ أسماء شوقي النجار[2]
1- قسم إنتاج الدواجن - كلية الزراعه - جامعه الاسكندرية - مصر
2- قسم الإنتاج الحيواني والداجني – كليه الزراعة – جامعة دمنهور- مصر

أجريت هذه الدراسة في وحدة بحوث الدواجن بمزرعه البستان، قسم الانتاج الحيواني والداجني، كلية الزراعة - جامعة دمنهور وكان الهدف منها تقييم التأثيرات الناتجة عن إضافة مستويات مختلفة من قشر الرمان علي الصفات الانتاجية والصفات الهيماتولوجيه وبروتينات الدم وكذلك صفات الذبيحه لكتاكيت اللحم. تم استخدام 180 من كتاكيت التسمين عشوائيا بداية من عمر أسبوع وحتى عمر 6 اسابيع واستخدمت خمسه معاملات تجريبيه بكل معاملة 36 طائر في سته مكررات بكل منها 6 كتاكيت علي النحو التالي: المجموعة الاولى هى الضابطة (الكنترول) وكانت بدون إضافات؛ والمعاملات الاربعه الاخري تغذت على العليقه الأساسيه مع اضافه قشر الرمان بمستويات 0.25 – 0.50- 1.00-1.50 % لكل كجم علي التوالي. أظهرت النتائج حدوث زيادة معنوية في وزن الجسم الحي ومعدل الزيادة في وزن الجسم مع تحسن في الكفاءة الغذائية وكذلك تحسن في النسبه المئويه للتصافي في المجموعات التي غذيت علي المستويات المختلفه من قشر الرمان بالمقارنة بمجموعة الكنترول. كما أظهرت النتائج انخفاض معنوي في مستوي AST-ALT في المجموعات المغذاة علي مستويات قشر الرمان. لوحظ أيضا وجود زيادة في مستوي البروتين الكلي- الجلوبيولين في سيرم الدم في المجموعات المغذاة علي قشر الرمان بالمستويات السابقه. قد خلصت نتائج الدراسة إلي أن إضافة المستويات من قشر الرمان كان لها تأثير ايجابي ومعنوي على الأداء الإنتاجي وبعض الصفات الفسيولوجيه لكتاكيت التسمين دون أي آثار سلبية على معايير الدم لكتاكيت التسمين.